Virtual Test Bed for Evaluating Wave Prediction Technology

Vincent J. Cardone and Andrew T. Cox
Oceanweather Inc.
5 River Road
Cos Cob, CT 06807
Phone: 203-661-3091 fax: 203-661-6809 email: oceanwx@oceanweather.com

Award #: N00014-98-C-0135

LONG-TERM GOAL

This contract supports a part of a larger program of applied research whose ultimate goal is to significantly improve our ability to predict ocean waves in deep and shallow water environments. That larger program is organized under ONR's Advanced Wave Prediction Program. The specific part of that program of which our effort is a part addresses the development of a "virtual test bed for evaluating wave prediction technology". This "test bed" project responds to the fact that there have been no significant advances in operational wave modeling and prediction since the introduction of the WAM model over a decade ago. The test bed is intended to stimulate scientists to systematically investigate, implement and test more advanced algorithms (source terms) which simulate wave growth, interaction and dissipative processes in deep and shallow water wave prediction models and to provide a rational objective framework to evaluate the efficacy of model enhancements.

This test bed program is a coordinated collaborative effort between scientists at Oceanweather Inc., the U.S. Army Corps of Engineers Waterways Experiment Station (WES) Coastal Engineering Research Center (CERC), U.S. Naval Research Laboratory (NRL), and Delft Technical University.

SPECIFIC OBJECTIVES

The specific objectives of Oceanweather's component of the test bed program may be succinctly stated as follows: (1) contribute to the identification and selection of the real historical scenarios to be used to populate the virtual test bed, taking into account at least the following: potential accuracy of wind inputs, suitability of bathymetry, availability and accuracy of measured wave data, spatial and temporal scales of the wave field; (2) for each selected case requiring post-analysis wind fields, develop the most accurate wind fields possible, given the available data base, using detailed kinematic reanalysis; (3) contribute to the assembly and processing of the measured wave data to be used to evaluate the wave model simulations: (4) contribute to the design of the statistical package to be developed for the test bed for objective model evaluations ; (4) contribute to the testing, evaluation and documentation of a prototype virtual test facility to be implemented at WES and NRL in anticipation of its transfer to other systems.

WORK COMPLETED

Work for FY2000 included the analysis of additional storm periods, delivery of wind fields for the test bed, reprocessing of measurement data, and hindcast of wind fields for a continuous year of the Gulf of

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **SEP 2000**	2. REPORT TYPE	3. DATES COVERED **00-00-2000 to 00-00-2000**

4. TITLE AND SUBTITLE **Virtual Test Bed for Evaluating Wave Prediction Technology**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Oceanweather Inc.,,5 River Road,,Cos Cob,,CT,06807**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S)
	11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**4**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Mexico. In the Northeastern Pacific, 15 storms were identified as candidates for the test bed in the storm selection performed in FY1999. A wind grid was setup covering the domain 20 to 60N, 180 to 255E with a uniform degree spacing of .625 degrees. This grid was selected to match the "storm domain" of the WIS (Wave Information Study) wave grid. Coastal effects will be later modeled on a higher resolution grid covering the coastal region of North America. Storm periods of up to one month were used for each storm to provide sufficient spin-up time for the wave model. Wind inputs were then assembled and adjusted to a 10-meter reference level for inclusion into the Wind WorkStation (WWS). Wind inputs included NCEP/NCAR reanalysis winds, US and Canadian buoys, ship reports, ERS 1/2 altimeter and scatterometer winds, NSCAT scatterometer winds, TOPEX altimeter winds. All these inputs were then used in a man-intensive kinematic analysis of the marine surface wind field. Figure 1 shows a sample WWS wind field for a storm during December of 1995.

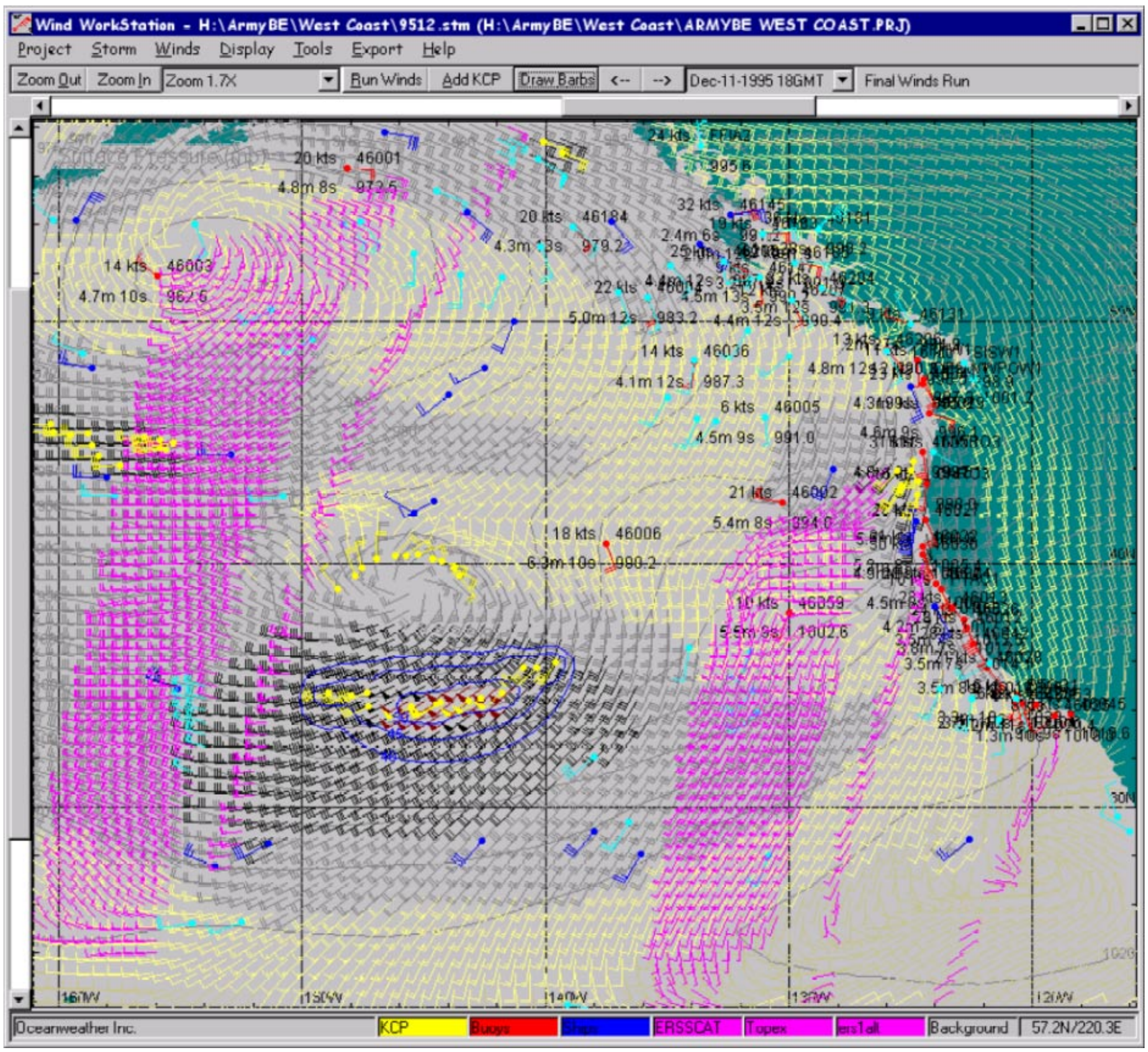

Figure 1. Wind WorkStation display of a Pacific storm during December 1995 (wind barbs in knots). Wind inputs from insitu and satellite measurement platforms are color-coded by type; kinematic control points (in yellow) are inputs from a marine meteorologist. An average of 30 man-hours per storm was expended in the kinematic analysis of each storm period in order to produce the best possible wind field for the wave model test bed.

Another milestone achieved in FY2000 was the first delivery of wind fields and measurement data for the test bed. Wind fields previously developed for SWADE IOP-1, the "Halloween" storm, and hurricanes Gordon (1994), Felix (1995), Fran (1996), Luis (1997) and Georges (1998) were processed and delivered for inclusion into the test bed. Additionally, altimeter wind and wave measurements were processed and delivered to WES as part of the test bed. Measurements from ERS-1, ERS-2 and TOPEX instruments were decoded from the source datasets and rigorously quality controlled. To make the database more manageable for wave model comparison, the individual measurements were binned on a global 55 km grid using a 30-minute time window. Measurements from each platform were adjusted using regressions based on buoy and satellite matched pairs. The goal of the regression/corrections is to make each measurement platform consistent with buoy measurements and to reduce the bias of any individual satellite measurement. The resulting database was delivered on 5 CD-ROMs and is ready for inclusion/comparison of test-bed wave simulations.

One of the future goals of this project is to develop a continuous year of winds for the globe. It was decided to test and develop various wind field corrections in the Gulf of Mexico before tackling the larger global problem. A Gulf of Mexico comparison of NCEP/NCAR winds vs. buoy winds and NSCAT scatterometer winds was performed. This comparison showed coherent regions of bias in the Gulf. The mid-Gulf tended to agree the most, while the western Gulf NCEP/NCAR winds underestimated the measured winds. Using the NSCAT scatterometer winds, corrections for each gridpoint were developed and applied to a continuous winds field for 1995. Buoys and tropical model winds from a boundary layer model were blended into the final wind fields, but no kinematic analysis was performed. Initial comparisons of the resulting waves show marked improvement over simulations using the raw NCEP/NCAR wind fields in both the mean and peak waves.

In the North Atlantic a previous hindcast, the AES40, was available for the continuous year test case. While AES40 involved kinematic analysis, it did so on a .625 by .833 degree North Atlantic grid at 6-hourly intervals. When this wind field was run on the WIS 1/12th degree level-3 US East Coast grid, some short-lived wave events were missed, particularly at the near-coast. To add an additional level of information to the AES40 base wind fields, the WWS was setup on a .25 degree wind grid to match the WIS level 2 domain (US East Coast). Additional kinematic analysis was performed on a 3-hourly timeframe and buoys and tropical winds were assimilated on an hourly time scale. The resulting wave hindcast shows very good agreement at all the US buoys, including coastal locations and properly simulates shorter-duration events missed in the original 6-hourly wind fields.

PLAN FOR NEXT CONTRACT PERIOD

Work for FY2001 will be concentrated on additional wind fields for the test bed and evaluation of the Pacific wind fields. An additional 17 events have been selected for the U.S. East Coast, a kinematic analysis similar to the Pacific storms will be applied. An evaluation of the Pacific wind fields already completed will be performed using the WES Pacific wave model.

In support of developing a full year of global winds, further refinement of the bias correction using QUIKSCAT scatterometer data will be performed. Corrections to wind speed by wind direction and bias corrections to the wind direction field itself will be explored and tested.